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ABSTRACT

This study examined the mode of locomotion preschoolers used to traverse fence-like barriers of various heights in order to reach a goal. Preschoolers could step over the barrier, crawl under it, or walk under it. The experimental situation consisted of a room with four fences set up at different heights. Two age groups of preschool children between 3.5 and 5 years of age and a group of adults were asked to retrieve a small toy block from behind single "rail" fences which varied in height in steps of 15.2 cm from 15.2 cm above the floor to about head height. Each retrieval resulted in two traversals: going and returning. Over the course of 24 trials, at least three retrievals or six traversals were made at each height. In general, all three modes of locomotion were observed. For very low heights, all subjects stepped over the fence. For very high heights, nearly all children and adults walked under the fence. For intermediate heights, all children crawled under the fence. For intermediate heights, adults were much more reluctant to crawl; some avoided that mode of locomotion completely. Results suggest that the locomotor behaviors of young children and adults may be constrained by environmental conditions in relation to body size. (RH)

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To Go Over or Under

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The ecological approach of James Gibson toward the study of perception enphasizes the sensivity of organisms to the relations between themselves and the environment. The most important features of such relations are the possibilities for action afforded by the environment. That perspective leads naturally to a focus on perception in the service of action. Warren's (1984) study of the perception of the climbability of stairs of different riser heights is an intriguing example of this approach. He found adults quite sensitive to the riser heights of stairs that they could most comfortably and efficiently climb. The approach has been extended to young children with the study of crawlers' choice of stairs they would mount (Thelen), with the study of toddlers' choice of aperatures of different sizes through which they would locomote (Palmer), and with the study of toddlers' and infants' choice of surfaces across which they would locomote (Gibson). In general, even young children "vote with their feet" and show by their action a remarkable sensitivity to the behavioral possibilities of their environment.

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The present study is in this same tradition. The mode of locomotion preschoolers use to traverse a fence-like barrier of different heights to reach a goal was examined. Mode of locomotion is an interesting measure in that it can take on a variety of qualitatively different forms, in the present case, stepping over the barrier, crawling under it, or walking under it. The photographs

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portray examples of the stepping-over and crawling-under modes.

(INSERT PHOTOGRAPHS HERE)

Method

Two age groups of preschool children (3 1/2 years and 5 years) and a group of adults were asked to retrieve a small toy block from behind single "rail" fences which were varied randomly in height in steps of 15.2 cm from 15.2 cm above the floor to about head height. The experimental situation consisted of a room with four fences set up at different heights. The child subjects retrieved a block from behind each of these fences in sequence and then had a chance to play with the blocks while the heights of the fences were changed. (The adults also retrieved the blocks but mostly did not engage in playing with them while the next set of fences was being set up.) In this way each retrieval resulted in two traversals: going and returning. Over the course of 24 trials at least three retrievals or six traversals were made at each height.

Results

In general, the three modes of locomotion are all observed. For very low heights all subjects stepped over the fence. For very high heights practically all children and adults walked under the fence and for intermediate heights all children crawled and/or crept under the fence. For the intermediate heights adults were much more reluctant to crawl; some avoided that mode of locomotion completely.

What is the best way to characterize these changes in mode of locomotion? One index would be the height at which a transition

between one mode and another occurred. For example, as the height of the fence is increased from its lowest position (15.2 cm. above the floor) it will reach some value at which a subject can no longer step over and will locomote under instead. That height will define an "over-under" transition point. An example of such transition points for each age can be numerically and graphically seen in Figure 1a, b, & c. There the lines marked with open squares (and labeled "from

(INSERT FIGURE 1a, b, & c HERE)

over") represents the percent of trials on which the subject went over the "fence rail" as a function of the height of the rail relative to leg length. The numerical value of the transition point can be arbitrarily defined as the relative height at which 50% of the crossings would be accomplished by going over. In the example of Figure 1a this would be at a relative height of approximately .75.

The lowest fence heights which are too high to step over are nevertheless typically too low to walk easily under. Most children and a good many adults resort to a crawling mode of locomotion. As the height of the rail is further increased for these subjects it eventually reaches a point at which they prefer to walk rather than crawl under the barrier. This defines a second, crawling-walking transition point. That can be defined again numerically and graphically at the 50% value of the diamond marked line of Figure 1a (labeled "to walk under") and is approximately 1.65.

The average transition points for the three age groups are shown in Figure 2. The line marked with open squares (the lower function)

(INSERT FIGURE 2 HERE)

represents the over-to-under transition. It can be seen that this is rather flat across the entire age range. That is, subjects make the over-under change of mode of locomotion at approximately the same fence height relative to their leg length (between .8 and .9). In contrast, the change from crawling under to walking under (the upper function marked with diamonds) is flat over the preschool ages but shows a decrease for the adults. The over-under transition apparently reflects constraints of body size. One simply can't easily or comfortably go over a rail higher than one's leg length. On the other hand, the change with age for adults in the second transition point may reflect a more culturally specified aversion of adults to crawling or perhaps the greater physical awkwardness of a taller adult getting down on hands and knees.

Besides these transition points the slopes of the cumulative functions (Figure 1) are also of some interest. A sharp or steep slope would suggest considerable precision in choosing a mode of locomotion in relation to relative body height whereas a gradual or shallow slope would suggest ambivalence or variability. The average slopes of these functions as a function of age are plotted in Figure 3. It is evident that the average slopes for both transition point

(INSERT FIGURE 3 HERE)

functions for both groups of children are about the same and considerably less steep than the slopes for the adults. That is, as expected, the adults displayed more precision than the children. Interestingly, for the adults the slope value for going over to under

was higher than for crawling-under-to-walking-under, again perhaps reflecting some greater measure of choice and ambiguity in deciding whether to crawl or walk under.

Age differences were also prominent in the "errors" children make in contacting the fence railing or having to hold on to a fence post for support during their traversals. Here the younger children made significantly more errors than the older children or adults. See Figure 4.

(INSERT FIGURE 4 HERE)

Conclusions

These results suggest that the locomotor behaviors of young children and adults may be interestingly constrained by environmental conditions in relation to body size. They do not indicate what information is specifying the body scaled height values that are the transition points. A good candidate for such information is the eyeheight ratio identified by Warren and Whang (1987) as relevant for subjects traversing aperatures of various widths. Further work manipulating the availability of information may verify this. Further evidence for the body scaling of the transition points may also be obtained from artificial modification of body dimensions, a manipulation that is currently under study in our laboratory.

The choice of mode of locomotion such as occurs in the situation under investigation here is one that is confronted in many natural settings. Little is known about the variables which influence that

choice. However, good candidates for such influence would be phsycial agility and task demands. For example, physical handicap would be very likely to change the relative heights at which mode of locomotion is changed as would increased need for maintaining steady balance such as in carrying an open container of liquid. The transition point and slope measures of the present study can provide sensitive indices for investigation of such factors.

FIGURE 1a

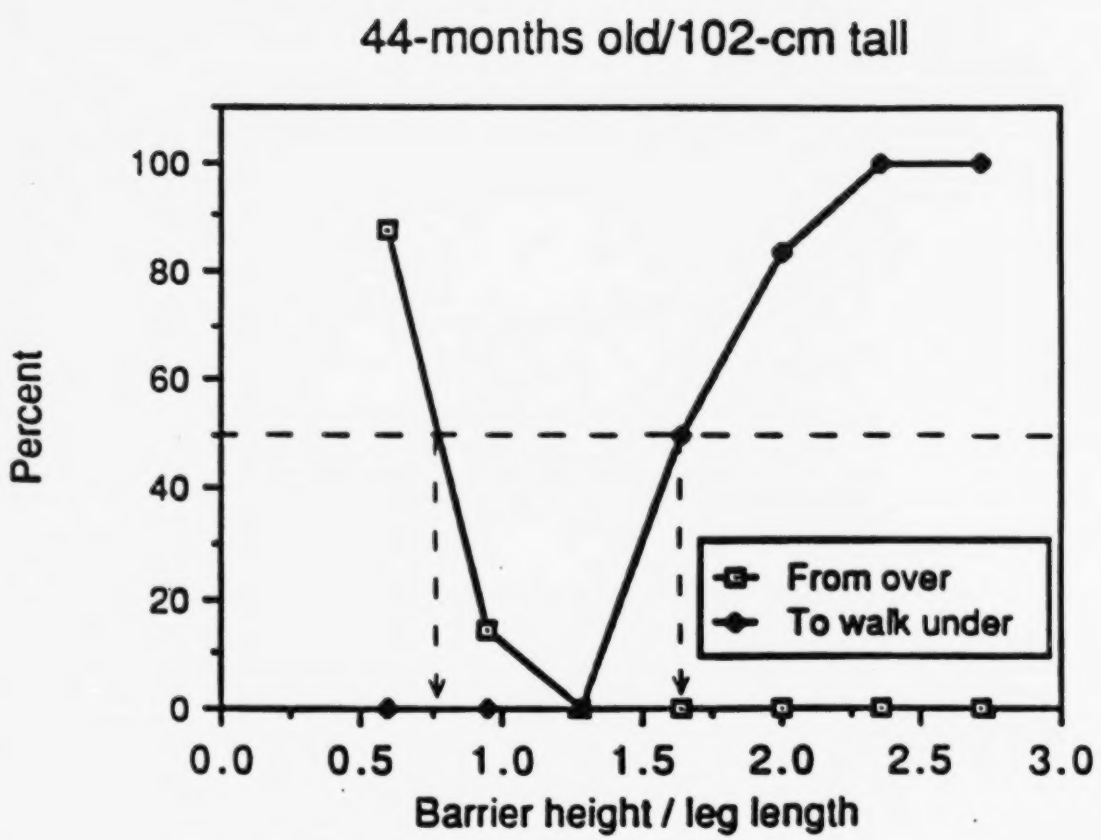
44-months old/102-cm tall
Percent
100
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Barrier height / leg length
From over
To walk under

FIGURE 1b

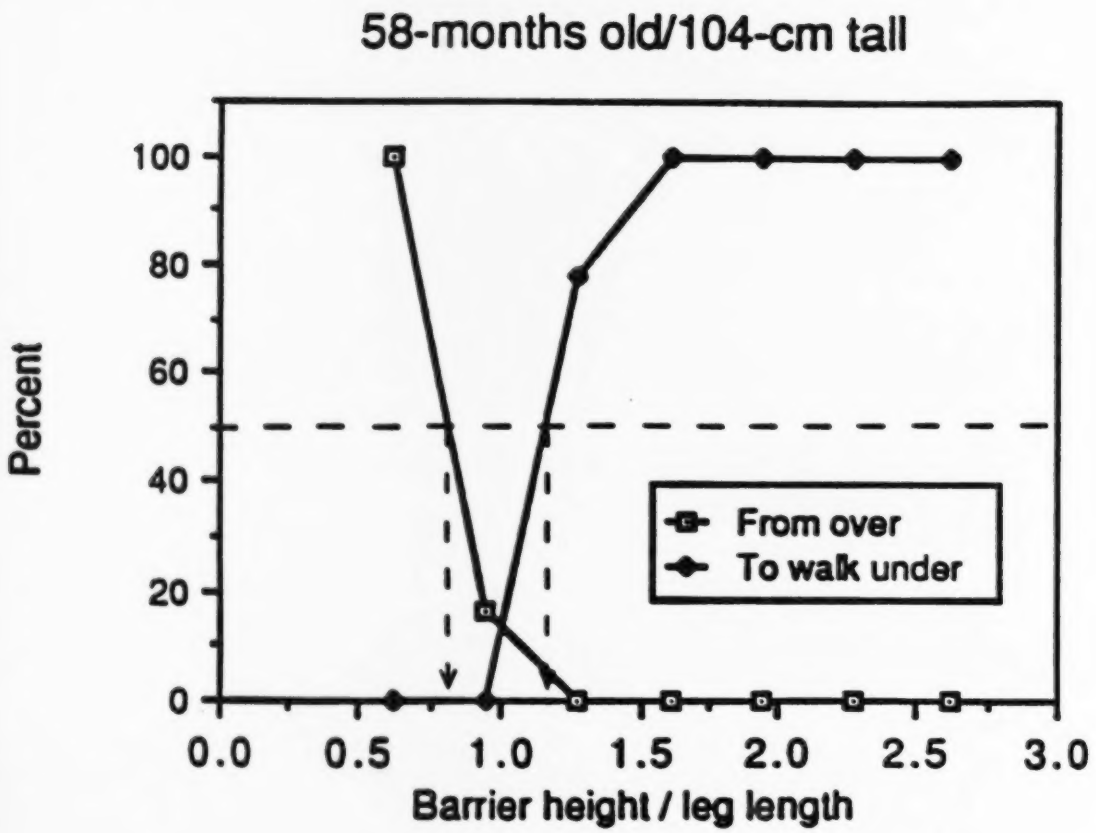
58-months old/104-cm tall
Percent
100
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Barrier height / leg length
From over
To walk under

FIGURE 1c

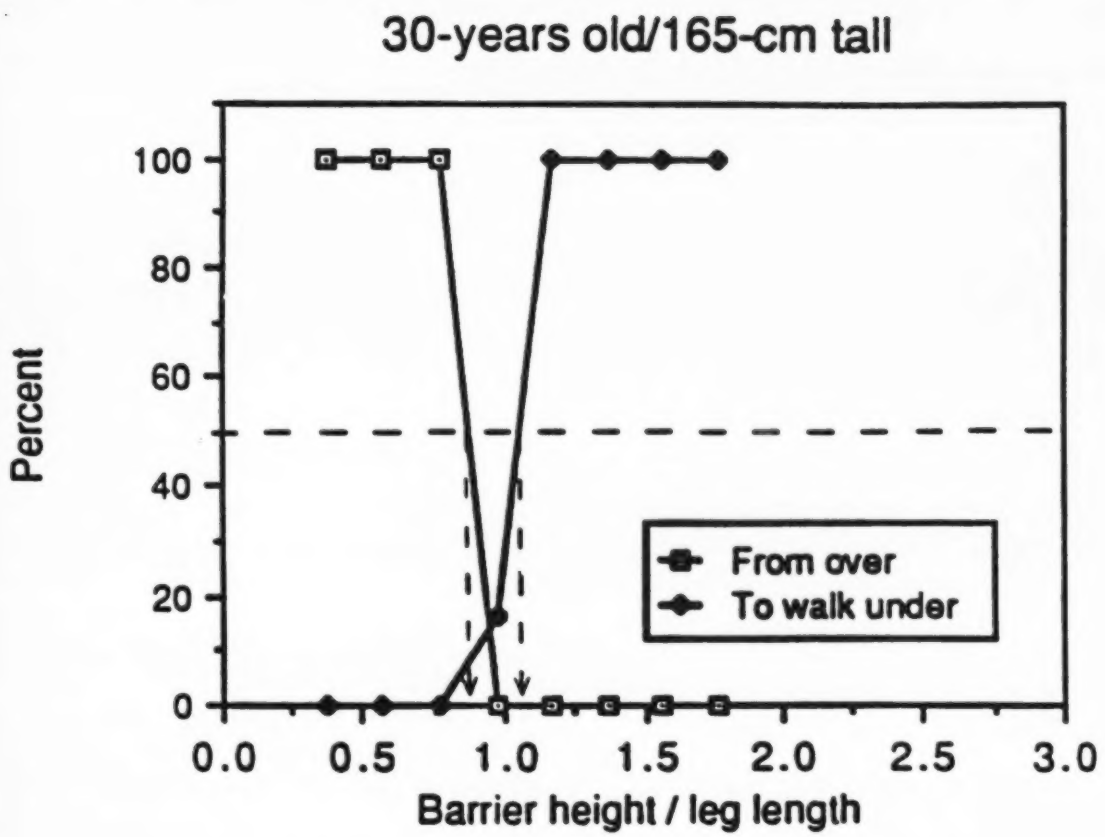
30-years old/165-cm tall
Percent
100
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Barrier height / leg length
From over
To walk under

FIGURE 2

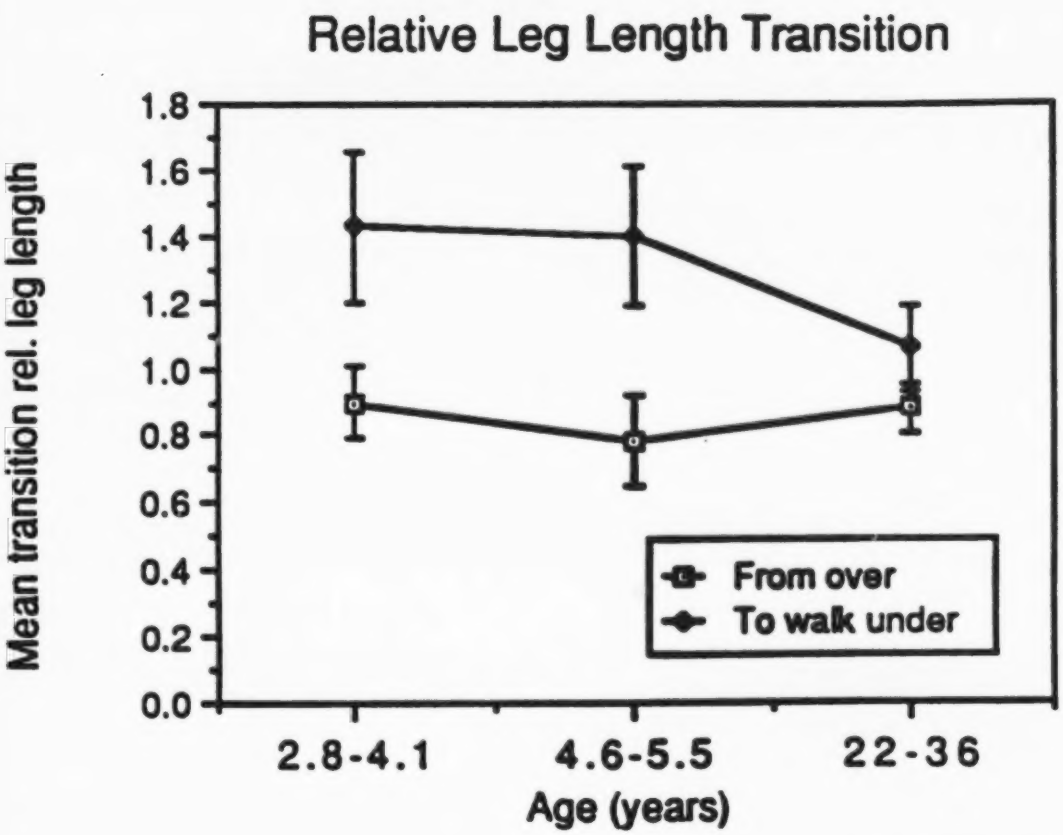
Relative Leg Length Transition
Mean transition rel. leg length
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
From over
To walk under
2.8-4.1
4.6-5.5
22-36
Age (years)

FIGURE 3

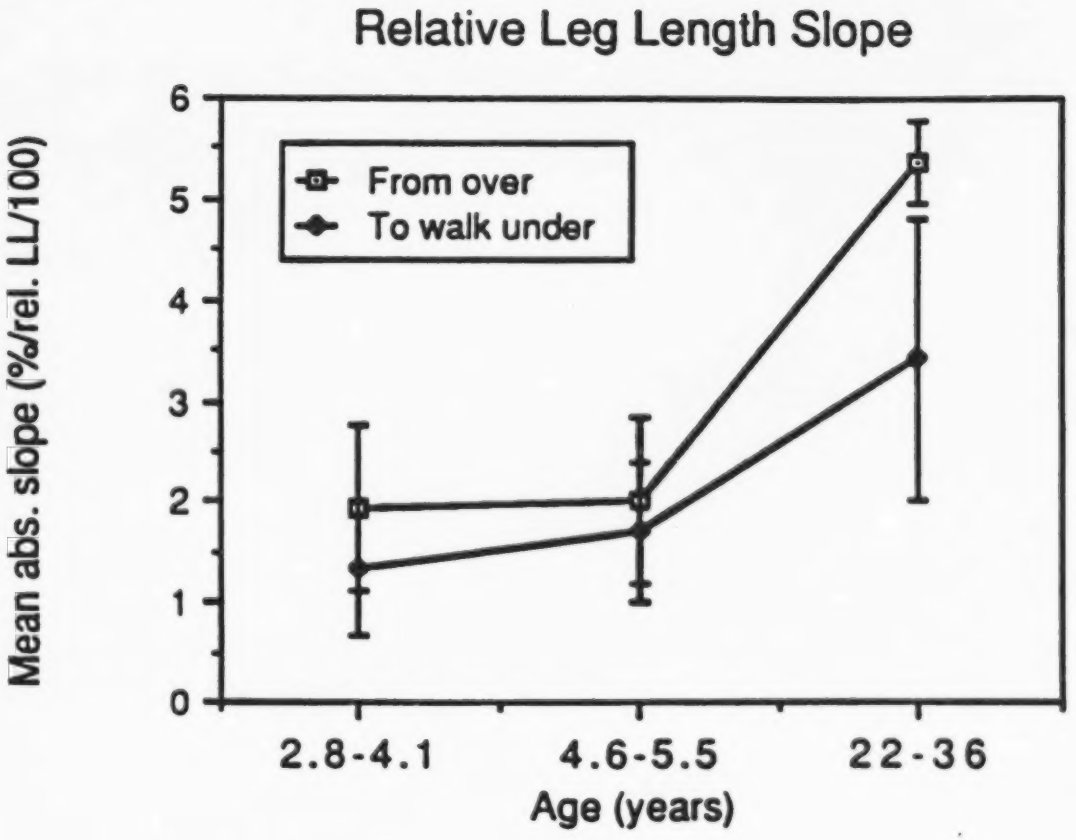
Relative Leg Length Slope
Mean abs. slope (%/rel. LL/100)
From over
To walk under
0
1
2
3
4
5
6
2.8-4.1
4.6-5.5
22-36
Age (years)

FIGURE 4

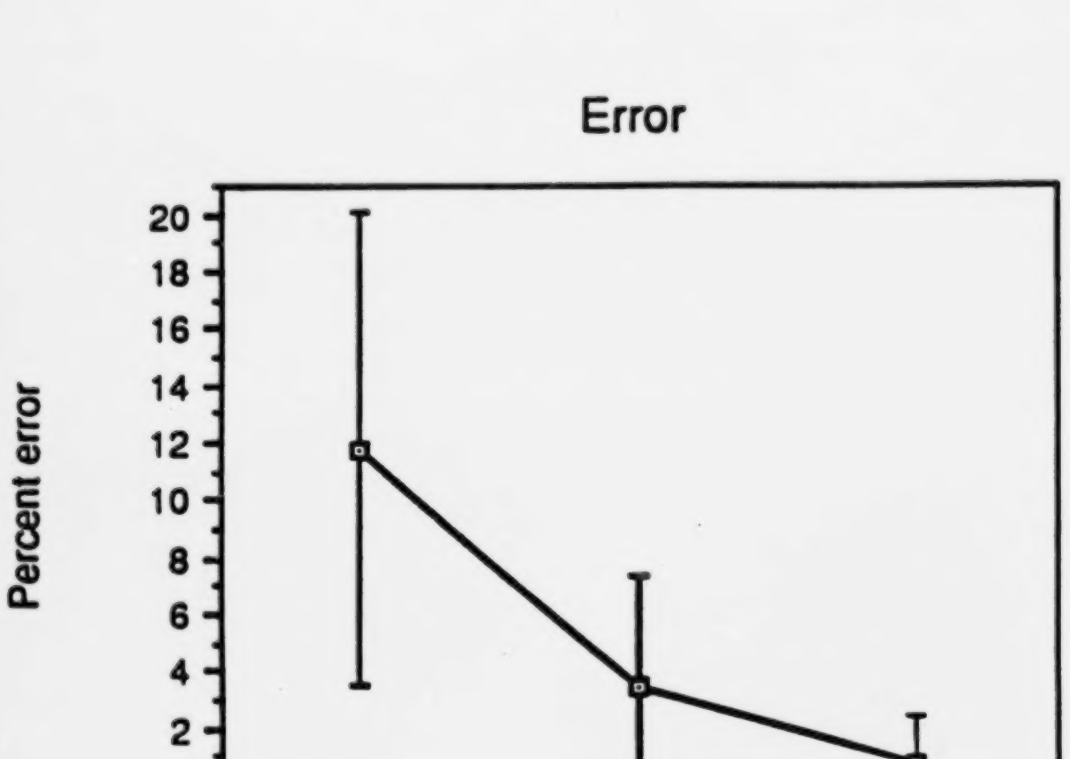
Error
Percent error
20
18
16
14
12
10
8
6
4
2
0
2.8-4.1
4.6-5.5
22-36
Age (years)

Table 1

Body Part Scoring System Reflecting the Number of Body Parts in Contact With Floor as the Barrier is Crossed and the Most Common Movement Behaviors For Each Score

Body Part Score	Most Common Movement Behavior
0	Jump, leap, or hop over
1	Step over
2	Walk under
3	Walk under plus one hand on floor
4	Under with two feet and hands on floor
5	Under with two feet and hands plus one knee on floor
6	Under with two feet, hands, and knees on floor ("creep")
7	Never observed
8	Under with two feet, hands, knees, and elbows on floor
9	Under with two feet, hands, knees, elbows, and trunk on floor ("crawl")